

### Claims

1. A method of processing spread spectrum signals comprising:  
receiving a continuous signal ( $S_{IF}$ ) of a comparatively high  
5 frequency,  
sampling the continuous signal ( $S_{IF}$ ) at a basic sampling rate ( $r_s$ ), whereby a resulting sequence of time discrete signal samples ( $S[s_i]$ ) is produced,  
quantising each signal sample into a corresponding level-  
10 discrete sample value,  
forming of a plurality of data words ( $d(1), \dots, d(N)$ ) which each includes one or more consecutive sample values ( $s_1, \dots, s_n$ ), and  
correlation between information in the data words ( $d(k)$ ) and  
15 at least one representation ( $CS(i)$ ) of a signal source specific code sequence ( $CS$ ), **characterized by**  
the method comprising a preparation for the correlation step, wherein, before receiving the continuous signal ( $S_{IF}$ ), a multitude of code vectors ( $CV; CV_m$ ) are pre-generated, each code vector representing a particular code sequence ( $CS(i)$ ) of the at least  
20 one signal source specific code sequence ( $CS$ ), and  
the correlation step involving multiplying at least each vector in a sub-group ( $CV_{m-E}, CV_{m-P}; CV_{m-L}$ ) of the code vectors ( $CV; CV_m$ ) with at least one vector ( $S_{IF-I}(k); S_{IF-Q}(k)$ ) derived from the  
25 data word ( $d(k)$ ).
2. A method according to claim 1, **characterized by** each code vector ( $CV; CV_m$ ) representing a particular signal source specific code sequence ( $CS(i)$ ) being sampled at the basic sampling rate ( $r_s$ ) and quantised with the quantising process being  
30 used to produce the level-discrete sample values ( $s_1, \dots, s_n$ ).
3. A method according to any one of the preceding claims, **characterized by** the at least one signal source specific code sequence ( $CS$ ) being pseudo random noise.

4. A method according to any one of the preceding claims, **characterized by** the receiving step involving down conversion of an incoming high-frequency signal ( $S_{HF}$ ) to an intermediate frequency signal ( $S_{IF}$ ), the high-frequency signal ( $S_{HF}$ ) having a spectrum which is symmetric around a first frequency ( $f_{HF}$ ) and the intermediate frequency signal ( $S_{IF}$ ) having a spectrum which is symmetric around a second frequency ( $f_{IF}$ ) being considerably lower than the first frequency ( $f_{HF}$ ).
5. A method according to claim 4, **characterized by** the steps of:
  - 10 determining a maximum frequency variation ( $f_D$ ) of the second frequency ( $f_{IF}$ ) due to Doppler-effects,
  - defining a Doppler frequency interval ( $f_{IF-min} - f_{IF-max}$ ) around the second frequency ( $f_{IF}$ ), the Doppler frequency interval ( $f_{IF-min} - f_{IF-max}$ ) having a lowest frequency limit ( $f_{IF-min}$ ) equal to the difference between the second frequency ( $f_{IF}$ ) and the maximum frequency variation ( $f_D$ ), and a highest frequency limit ( $f_{IF-max}$ ) equal to the sum of the second frequency ( $f_{IF}$ ) and the maximum frequency variation ( $f_D$ ),
  - 15 dividing the Doppler frequency interval ( $f_{IF-min} - f_{IF-max}$ ) into an integer number of equidistant ( $\Delta f$ ) frequency steps ( $f_{IF-min}$ ,  $f_{IF-min} + \Delta f$ , ...,  $f_{IF-max}$ ), and
  - defining a frequency candidate vector ( $f_{IF-C}$ ) for each frequency step ( $f_{IF-min}$ ,  $f_{IF-min} + \Delta f$ , ...,  $f_{IF-max}$ ).
6. A method according to claim 5, **characterized by** the steps of:
  - 25 determining an integer number of initial phase positions ( $\Phi_0, \dots, \Phi_7$ ) for the frequency candidate vector ( $f_{IF-C}$ ), and
  - defining a carrier frequency-phase candidate vector ( $V_{f\Phi}(f_{IF-C}, \Phi_C)$ ) for each combination of carrier frequency candidate vector ( $f_{IF-C}$ ) and initial phase position ( $\Phi_0, \dots, \Phi_7$ ).
7. A method according to claim 6, **characterized by** the steps of:
  - 30 determining the number of elements ( $s_n$ ) in each carrier frequency-phase candidate vector ( $V_{f\Phi}(f_{IF-C}, \Phi_C)$ ), and

storing the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) according to a data format being adapted to performing multiplication operations between the data word ( $d(k)$ ) and a segment of a carrier frequency-phase candidate vector  
 5 ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ).

8. A method according to claim 7, **characterized by** the adapting of the data format involving adding at least one element to each segment of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) such that the segment attains a number of  
 10 elements which is equal to the number of elements in the data word ( $d(k)$ ), thus enabling a segment of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) and one of the at least one vector ( $S_{IF-I}(k)$ ;  $S_{IF-Q}(k)$ ) to be processed jointly by at least one of a SIMD-operation and an XOR-operation.

15 9. A method according to any one of the preceding claims, **characterized by** the steps of:

determining a maximum variation a code rate due to Doppler-effects,

defining a Doppler rate interval ( $CR_{C-min} - CR_{C-max}$ ) around  
 20 a center code rate ( $CR_C$ ), the Doppler frequency interval having a lowest code rate limit ( $CR_{C-min}$ ) equal to the difference between the center code rate ( $CR_C$ ) and the maximum code rate variation ( $CR_D$ ), and a highest frequency limit ( $CR_{C-max}$ ) equal to the sum of the center code rate ( $CR_C$ ) and the maximum code  
 25 rate variation ( $CR_D$ ),

dividing the Doppler rate interval ( $CR_{C-min} - CR_{C-max}$ ) into an integer number of equidistant ( $\Delta CR$ ) code rate steps ( $CR_{C-min}$ ,  $CR_{C-min} + \Delta CR$ , ...,  $CR_{C-max}$ ) and

defining a code rate candidate ( $CR_{C-C}$ ) for each code rate  
 30 step ( $CR_{C-min}$ ,  $CR_{C-min} + \Delta CR$ , ...,  $CR_{C-max}$ ).

10. A method according to claim 9, **characterized by** determining an integer number of possible initial code phase positions

(0.0, ..., 0.9) for each code rate candidate ( $CR_{C-C}$ ).

11. A method according to claim 10, **characterized by** defining, for each signal source specific code sequence ( $CS(i)$ ), a set of combinations between code rate candidate ( $CR_{C-C}$ ) and  
5 code phase position (0.0, ..., 0.9), each combination representing a code rate-phase candidate vector.

12. A method according to claim 11, **characterized by** generating, for each signal source specific code sequence ( $CS(i)$ ), a set of code vectors ( $CV$ ) by:  
10 sampling each code rate-phase candidate vector with the basic sampling rate ( $r_s$ ) whereby a corresponding code vector ( $CV$ ) is produced.

13. A method according to any one of the preceding claims, **characterized by** generating a modified code vector ( $CV_m$ ) on  
15 basis of each code vector ( $CV$ ) by:

copying a particular number of elements ( $E_e$ ) from the end of an original code vector ( $CV$ ) to the beginning of the modified code vector ( $CV_m$ ), and

20 copying the particular number of elements ( $E_b$ ) from the beginning of the original code vector ( $CV$ ) to the end of the code vector ( $CV_m$ ).

14. A method according to claim 13, **characterized by** storing, for each signal source specific code sequence ( $CS(i)$ ), a set of modified code vectors ( $\{CV_m(CR_{C-C}, Cph)\}$ ), where

25 each modified code vector ( $CV_m$ ) contains a number of elements ( $s_1, \dots, s_m$ ) representing a sampled version of at least one full code sequence ( $CS$ ),

a particular modified code vector ( $CV_m$ ) is defined for each combination of code rate candidate ( $CR_{C-C}$ ) and code phase  
30 position ( $Cph$ ).

15. A method according to claim 14, **characterized by** adapting the data format of the modified code vectors ( $CV_m$ ) with respect to the data format of the at least one vector ( $S_{IF-I}(k)$ ;  $S_{IF-Q}(k)$ ) derived from the data word ( $d(k)$ ), such that a modified  
5 code vector ( $CV_m$ ) and one of the at least one vector ( $S_{IF-I}(k)$ ;  $S_{IF-Q}(k)$ ) may be processed jointly by at least one of a SIMD-operation and an XOR-operation.

16. A method according to any one of the claims 14 or 15, **characterized by** involving an initial acquisition phase and a  
10 subsequent tracking phase, wherein during the acquisition phase a set of preliminary parameters are established which are required for initiating a decoding of signals received during the tracking phase, a successful acquisition phase resulting in at least one signal source specific code sequence (CS) being identi-  
15 fied and a transmitted signal being rendered possible to track, each of the at least one signal source specific code sequence (CS) being associated with tracking characteristics in the form of:  
a modified code vector ( $CV_m$ ),  
a carrier frequency candidate vector ( $f_{IF-C}$ ),  
20 an initial phase position ( $\Phi_C$ ),  
a code phase position (Cph), and  
a code index (CI) denoting a starting sample value for the modified code vector ( $CV_m$ ).

17. A method according to claim 16, **characterized by** the  
25 tracking involving:

calculating, based the tracking characteristics, a prompt pointer ( $P_P$ ) for each modified code vector ( $CV_m$ ), the prompt pointer ( $P_P$ ) indicating a code sequence start position, and an initial prompt pointer ( $P_P$ ) being equal to the code index (CI), and  
30 assigning, around each prompt pointer ( $P_P$ ), at least one pair of early- and late pointers ( $P_E, P_L$ ;  $P_{E1}, P_{L1}$   $P_{E2}, P_{L2}$ ), where the early pointer ( $P_E$ ) specifies a sample value being positioned at least one element before the prompt pointer's ( $P_P$ ) position,

and the late pointer ( $P_L$ ) specifies a sample value being positioned at least one element after the prompt pointer's ( $P_P$ ) position.

18. A method according to claim 17, **characterized by** the  
5 tracking involving:

receiving a sequence of incoming level-discrete sample values (1210),

forming data words ( $d(1), \dots, d(N)$ ) of the sample values (1210) such that each data word ( $d(k)$ ) contains a number of  
10 elements which is equal to the number of elements ( $s_n$ ) in each carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ),

calculating a relevant set of carrier frequency-phase candidate vectors ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) for the data word ( $d(k)$ ), and

acquiring, for each carrier frequency-phase candidate  
15 vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) in the relevant set, a pre-generated in-phase representation ( $f_{IF-I}$ ) and a quadrature-phase representation ( $f_{IF-Q}$ ) of the vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) respectively.

19. A method according to claim 18, **characterized by** the tracking involving:

20 multiplying each data word ( $d(k)$ ) with the in-phase representation ( $f_{IF-I}$ ) of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) in the relevant set to produce a first intermediate-frequency-reduced information word ( $S_{IF-I}(k)$ ),

25 multiplying each data word ( $d(k)$ ) with the quadrature-phase representation ( $f_{IF-Q}$ ) of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \phi_C)$ ) in the relevant set to produce a second intermediate-frequency-reduced information word ( $S_{IF-Q}(k)$ ).

20. A method according to claim 19, **characterized by** the tracking involving:

30 multiplying the first intermediate-frequency-reduced information word ( $S_{IF-I}(k)$ ) with a modified code vector ( $CV_{m-P}(k)$ ) starting at a position indicated by the prompt pointer ( $P_P$ ) to

produce a first prompt-despread symbol string ( $\Lambda_{IP}(k)$ ),

5 multiplying the first intermediate-frequency-reduced information word ( $S_{IF-I}(k)$ ) with a modified code vector ( $CV_{m-E}(k)$ ) starting at a position indicated by an early pointer ( $P_E$ ) to produce a first early-despread symbol string ( $\Lambda_{IE}(k)$ ),

multiplying the first intermediate-frequency-reduced information word ( $S_{IF-I}(k)$ ) with a modified code vector ( $CV_{m-L}(k)$ ) starting at a position indicated by a late pointer ( $P_L$ ) to produce a first late-despread symbol string ( $\Lambda_{IL}(k)$ ),

10 multiplying the second intermediate-frequency-reduced information word ( $S_{IF-Q}(k)$ ) with a modified code vector ( $CV_{m-P}(k)$ ) starting at a position indicated by the prompt pointer ( $P_P$ ) to produce a second prompt-despread symbol string ( $\Lambda_{QP}(k)$ ),

15 multiplying the second intermediate-frequency-reduced information word ( $S_{IF-Q}(k)$ ) with a modified code vector ( $CV_{m-E}(k)$ ) starting at a position indicated by the early pointer ( $P_E$ ) to produce a second early-despread symbol string ( $\Lambda_{QE}(k)$ ), and

20 multiplying the second intermediate-frequency-reduced information word ( $S_{IF-Q}(k)$ ) with a modified code vector ( $CV_{m-L}(k)$ ) starting at a position indicated by the late pointer ( $P_L$ ) to produce a second late-despread symbol string ( $\Lambda_{QL}(k)$ ).

21. A method according to claim 20, **characterized by** the tracking involving deriving, for each despread symbol string, a resulting data word ( $D_{R-IP}(k)$ ,  $D_{R-IE}(k)$ ,  $D_{R-IL}(k)$ ,  $D_{R-QP}(k)$ ,  $D_{R-QE}(k)$ ;  $D_{R-QL}(k)$ ).

22. A method according to claim 21, **characterized by** deriving the resulting data words ( $D_{R-IP}(k)$ ,  $D_{R-IE}(k)$ ,  $D_{R-IL}(k)$ ,  $D_{R-QP}(k)$ ,  $D_{R-QE}(k)$ ;  $D_{R-QL}(k)$ ) by looking up a respective pre-generated value in a table (1310).

23. A method according to any one of the claims 19 - 22, **characterized by** performing the multiplication between the data word ( $d(k)$ ) and the in-phase representation ( $f_{IF-I}$ ) of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \Phi_C)$ ) respective  
5 between the data word ( $d(k)$ ) and the a quadrature-phase representation ( $f_{IF-Q}$ ) of the carrier frequency-phase candidate vector ( $V_{f\phi}(f_{IF-C}, \Phi_C)$ ) by means of at least one of a SIMD-operation and an XOR-operation
24. A method according to any one of the claims 19 - 23, **characterized by** performing the multiplication between the inter-  
10 mediate-frequency-reduced information words ( $S_{IF-I}(k)$ ;  $S_{IF-Q}(k)$ ) and the modified code vectors ( $CV_{m-P}$ ,  $CV_{m-E}$ ;  $CV_{m-L}$ ) by means of at least one of a SIMD-operation and an XOR-operation.
25. A method according to any one of the claims 19 - 24, **characterized by** propagating, in connection with completing  
15 the processing of a current data word ( $d(k)$ ) and initiating the processing of a subsequent data word ( $d(k+1)$ ):  
a pointer ( $p_d$ ) indicating a first sample value of the subsequent data word ( $d(k+1)$ ),  
20 a group of parameters describing the relevant set of carrier frequency-phase candidate vectors ( $V_{f\phi}(f_{IF-C}, \Phi_C)$ ),  
the relevant set of code vectors ( $CV_m$ ), and  
prompt-, early-, and late pointers ( $P_P$ ,  $P_E$ ,  $P_L$ ).
26. A computer program directly loadable into the internal  
25 memory of a computer, comprising software for controlling the steps of any of the claims 1 - 25 when said program is run on the computer.
27. A computer readable medium, having a program recorded thereon, where the program is to make a computer control the  
30 steps of any of the claims 1 - 25.



28. A signal receiver (1500) for receiving navigation data signals transmitted in a navigation satellite system comprising:

5 a radio front end unit (1510) adapted to receive a continuous radio signal ( $S_{HF}$ ) and in response thereto produce a corresponding electrical signal ( $S_{IF}$ ) comparatively high frequency,

an interface unit (1520) adapted to receive the electrical signal ( $S_{IF}$ ) and in response thereto produce a sequence of sample values being divided into data words ( $d(k)$ ), and

10 a digital processor unit (1530) adapted to receive the data words ( $d(k)$ ) and in response thereto demodulate a data signal, and including a memory means (1535), **characterized in that** a computer program according to claim 26 is loaded into the memory means (1535).

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